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Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE**UTILITY
PATENT APPLICATION
TRANSMITTAL**

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No. 356972000203

Total Pages 33

First Named Inventor or Application Identifier

Kazufumi OGAWA, Nara-shi, JAPAN; Mamoru SOGA, Osaka, JAPAN

Title

Method of Manufacturing a Fluorocarbon-Based Coating Film

CERTIFICATE OF HAND DELIVERY

I hereby certify that this correspondence is being hand filed with the United States Patent and Trademark Office in Washington, D.C. on October 24, 2000.

Elizabeth K. Stenson
Elizabeth K. Stenson

PTO 09/694575

10/24/00

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO:

Assistant Commissioner for Patents
Box Patent Application
Washington, DC 20231

1. ☒ Fee Transmittal Form
(Submit an original, and a duplicate for fee processing)
2. ☒ Specification [Total Pages 19]
(preferred arrangement set forth below)
- Descriptive title of the Invention
- Cross References to Related Applications
- Statement Regarding Fed sponsored R & D
- Reference to Microfiche Appendix
- Background of the Invention
- Brief Summary of the Invention
- Brief Description of the Drawings (if filed)
- Detailed Description
- Claim(s)
- Abstract of the Disclosure
3. ☒ Drawing(s) (35 USC 113) [Total Sheets 8]
4. ☒ Oath or Declaration [Total Pages 4]
a. ☐ Newly executed (original or copy)
b. ☒ Copy from a prior application (37 CFR 1.63(d)
(for continuation/divisional with Box 17 completed)
[Note Box 5 below]
i. ☐ **DELETION OF INVENTOR(S)**
Signed statement attached deleting inventor(s) named in
the prior application, see 37 CFR 1.63(d)(2) and 1.33(b)
5. ☒ Incorporation By Reference (useable if Box 4b is checked)
The entire disclosure of the prior application, from which a copy of the
oath or declaration is supplied under Box 4b, is considered as being
part of the disclosure of the accompanying application and is hereby
incorporated by reference therein.

6. ☐ Microfiche Computer Program (Appendix)
7. ☐ Nucleotide and/or Amino Acid Sequence Submission
(if applicable, all necessary)
a. ☐ Computer Readable Copy
b. ☐ Paper Copy (identical to computer copy)
c. ☐ Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

8. ☐ Assignment Papers (cover sheet & document(s))
9. ☐ 37 CFR 3.73(b) Statement ☐ Power of Attorney
(when there is an assignee)
10. ☐ English Translation Document (if applicable)
11. ☐ Information Disclosure Statement (IDS)/PTO-1449 ☐ Copies of IDS Citations
12. ☒ Preliminary Amendment
13. ☒ Return Receipt Postcard (MPEP 503)
(Should be specifically itemized)
14. ☐ Small Entity ☐ Statement filed in prior application,
Statement(s) Status still proper and desired
15. ☐ Certified Copy of Priority Document(s)
(if foreign priority is claimed)
16. ☒ Copies of Supplemental Reissue Application Declaration
and Power of Attorney by Inventor; Reissue Application
Declaration and Power of Attorney by Inventor; Offer to
Surrender; Assent of Assignee

17. If a CONTINUING APPLICATION, check appropriate box and supply the requisite information:

☒ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No: 09/112,219**18. CORRESPONDENCE ADDRESS**Richard D. Jordan
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- ☒ If a paper is untimely filed in the above-referenced application by applicant or his/her representative, the Assistant Commissioner is hereby petitioned under 37 C.F.R. § 1.136(a) for the minimum extension of time required to make said paper timely. In the event a petition for extension of time is made under the provisions of this paragraph, the Assistant Commissioner is hereby requested to charge any fee required under 37 C.F.R. § 1.17(a)-(d) to **Deposit Account No. 03-1952**. However, the Assistant Commissioner is **NOT** authorized to charge the cost of the issue fee to the Deposit Account.

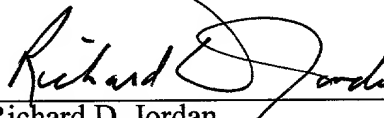
The filing fee has been calculated as follows:

FOR	NUMBER FILED	NUMBER EXTRA	RATE	CALCULATIONS
TOTAL CLAIMS	10 - 20 =	0	x \$18.00	\$0.00
INDEPENDENT CLAIMS	2 - 3 =	0	x \$80.00	\$0.00
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ \$270.00	\$N/A
			BASIC FEE	\$710.00
			TOTAL OF ABOVE CALCULATIONS =	\$710.00
Reduction by 1/2 for filing by small entity (Note 37 C.F.R. §§ 1.9, 1.27, 1.28). If applicable, verified statement must be attached.				\$N/A
Assignment Recording Fee (if enclosed)				\$N/A
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Dated: October 24, 2000

Respectfully submitted,

By: 
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CERTIFICATE OF HAND DELIVERY

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Elizabeth K. Stenson

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the application of:

Kazufumi OGAWA; Mamoru SOGA

Serial No.: To be assigned

Filing Date: October 24, 2000

For: METHOD OF MANUFACTURING A
FLUOROCARBON-BASED COATING
FILM

Examiner: To be assigned

Group Art Unit: To be assigned

PRELIMINARY AMENDMENT

Commissioner for Patents
Washington, D.C. 20231

Sir:

Please enter the following amendment.

In the Specification

Please amend the specification as follows.

Replace lines 4-7 of column 1 with the following:

--This application is a continuation of U.S. Application No. 09/112,219, which is a reissue application of U.S. Pat. No. 5,538,762, which is a continuation of U.S. application Ser. No. 08/052,913, filed Apr. 27, 1993, now abandoned, which was a division of application Ser. No.

Delete lines 1-8 of column 2 and replace with the following:

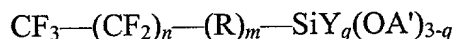
--where n represents 0 or an integer; R represents an [alkyl] alkylene group or a hydrocarbon substituted group containing C=C, C≡C, a silicon atom or an oxygen atom; m represents 0 or 1; Y represents a hydrogen atom, an alkyl group, an alkoxy group, a fluorine-containing alkoxy group or a fluorine-containing alkyl group; A represents a hydrogen atom; and q represents 0, 1 or 2; and, [and] baking the substrate after the contacting and coating steps.--

Starting at line 32 of column 2 and continuing to the end of that column, delete all lines, and replace with the following:

--It is preferable in this [method] invention that the material having a chlorosilyl group contains a member [of a] selected from the group consisting of SiCl₄, SiHCl₃, SiH₂Cl₂ and Cl—(SiCl₂O)_n—SiCl₃ (n being an integer, preferably 1 to 3).

It is preferable in this [method] invention that the compound having a fluorocarbon group and chlorosilyl group is represented by a formula: CF₃—(CF₂)_n—(R)_m—SiX_pCl_{3-p} where n represents 0 or an integer; R represents an [alkyl] alkylene group or a hydrocarbon substituted group containing C=C, C≡C, a silicon atom or a hydrogen atom; m represents 0 or 1; X represents a hydrogen atom, an alkyl group, an alkoxy group, a fluorine-containing alkoxy group or a fluorine-containing alkyl group; p represents 0, 1 or 2.

It is preferable in this [method] invention that the compound having a fluorocarbon group and an alkoxysilane group is represented by a formula:



where n represents 0 or an integer, R represents an [alkyl] alkylene group or a hydrocarbon substituted

group containing C=C, C≡C, a silicon atom or an oxygen atom; m represents 0 or 1; Y represents a hydrogen atom, an alkyl group, an alkoxy group, a fluorine-containing alkoxy group or a fluorine-containing alkyl group; OA' represents an alkoxy group; and q represents 0, 1 or 2.

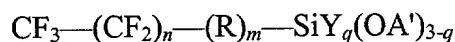
It is preferable in this [method] invention that the material represented by a formula: $\text{SiX}_s\text{Cl}_{4-s}$ where X represents a hydrogen atom or an alkyl group, and s represents 0, 1 or 2; is added to a non-aqueous solvent containing a compound having a fluorocarbon group and a chlorosilyl group.

It is preferable in this [method] invention that the material represented by a formula: $\text{SiY}_t(\text{OA}')_{4-t}$ where Y represents an alkyl group; A' represents a hydrogen atom or an alkyl group; and t represents 0, 1 and 2; is added to solvent containing a compound having a fluorocarbon group and an alkoxysilane group.--

Delete lines 23 through 62 of column 5 and replace with the following:

--As the compound having a fluorocarbon group and a chlorosilane group, those which may be used are represented by a formula: $\text{CF}_3-(\text{CF}_2)_n-(\text{R})_m-\text{SiX}_p\text{Cl}_{3-p}$ where n represents 0 or an integer; R represents an [alkyl] alkylene group or a hydrocarbon substituted group containing C=C, C≡C, a silicon atom or an oxygen atom; m represents 0 or 1; X represents a hydrogen atom, an alkyl group, an alkoxy group, a fluorine-containing alkoxy group or a fluorine-containing alkyl group; and p represents 0, 1 or 2.

As the compound having a fluorocarbon group and an alkoxysilane group, those which may be used are represented by a formula:



where n represents 0 or an integer; R represents an [alkyl] alkylene group or a hydrocarbon substituted group containing C=C, C≡C, a silicon atom or an oxygen atom; m represents 0 or 1; Y represents a hydrogen atom, an alkyl group, an alkoxy group, a fluorine-containing alkoxy group and a fluorine-

containing alkyl group, OA' represents an alkoxy group, and q represents 0, 1 or 2.

To harden the fluorocarbon-based polymer coating film to be formed, a cross-linking agent can be added.

More specifically, in the case where a non-aqueous solvent containing a compound having a fluorocarbon group and a chlorosilane group is used, a cross-linking which may be used is represented by a formula: $\text{SiX}_s\text{Cl}_{4-s}$, where X represents a hydrogen group or a substituted group, such as an alkyl group; and s represents 0, 1 or 2. In the case of using a solvent containing a compound having a fluorocarbon group and an alkoxysilane group, a cross-linking agent which may be used is represented by a formula: $\text{SiY}_t(\text{OA}')_{4-t}$, where Y represents a substituted group, such as an alkyl group; A' represents a hydrogen atom or an alkyl group; and t represents 0, 1 and 2. In either case, it is possible to adjust the three-dimensional cross-linking degree in the fluorocarbon-based polymer coating film that is formed, thus controlling the hardness of the fluorocarbon-based coating film.--

In the Claims

Please cancel claims 1-11.

Please enter the following new claims:

--12. A method of manufacturing a vehicle part comprising:

- a. contacting a vehicle part having a surface containing hydroxyl groups with a non-aqueous solvent comprising a material comprising chlorosilyl groups to form a siloxane-based film on the vehicle part surface; and
- b. coating the siloxane-based film with a non-aqueous solvent comprising a compound comprising a fluorocarbon group and a chlorosilyl group, represented by the formula: $\text{CF}_3-(\text{CF}_2)_n-(\text{R})_m-\text{SiX}_p\text{Cl}_{3-p}$ where n represents 0 or an integer; R represents an alkylene group or a hydrocarbon substituted group containing $\text{C}=\text{C}$ or $\text{C}\equiv\text{C}$, a silicon atom or an oxygen atom; m represents 0 or 1, X represents a hydrogen atom or an alkyl group; p represents 0, 1 or 2.

13. The method of claim 12, wherein said material comprising chlorosilyl groups is selected from the group consisting of SiCl_4 , SiHCl_3 , SiH_2Cl_2 and $\text{Cl}-(\text{SiCl}_2\text{O})_n-\text{SiCl}_3$, wherein n is an integer.

14. The method of claim 12, wherein p represents 0.

15. A vehicle part made by the method of claim 12.

16. A method of applying a fluorocarbon-based polymer coating film to an apparatus comprising:

a. contacting an apparatus having a surface containing hydroxyl groups with a non-aqueous solvent comprising a material comprising chlorosilyl groups to form a siloxane-based film on the apparatus surface; and

b. coating the siloxane-based film with a non-aqueous solvent comprising a compound comprising a fluorocarbon group and a chlorosilyl group, represented by the formula: $\text{CF}_3-(\text{CF}_2)_n-(\text{R})_m-\text{SiX}_p\text{Cl}_{3-p}$ where n represents 0 or an integer; R represents an alkylene group or a hydrocarbon substituted group containing $\text{C}=\text{C}$ or $\text{C}\equiv\text{C}$, a silicon atom or an oxygen atom; m represents 0 or 1, X represents a hydrogen atom or an alkyl group; p represents 0, 1 or 2.

17. The method of claim 16, wherein said material comprising chlorosilyl groups is selected from the group consisting of SiCl_4 , SiHCl_3 , SiH_2Cl_2 and $\text{Cl}-(\text{SiCl}_2\text{O})_n-\text{SiCl}_3$, wherein n is an integer.

18. The method of claim 16, wherein p represents 0.

19. The method of claim 16, wherein the apparatus is an electric apparatus, a vehicle or an industrial apparatus.

20. An apparatus made by the method of claim 16.

21. The apparatus of claim 20, wherein the apparatus is a vehicle.--

REMARKS

This application is a continuation of Applicants' Reissue Application No. 09/112,219 in which a Notice of Appeal has been filed. This application also corresponds to Reissue Application No. 09/614,073, which is also a continuation of the '219 application.

This Preliminary Amendment amends the specification exactly as in Applicants' '219 application. Claims 1-11 are now canceled. Claims 12-21 are newly added, with claims 12 and 16 being independent claims.

Independent claim 12 is to a method of manufacturing a vehicle part. Elements a and b of claim 12 are the same as elements a and b of claim 12 in the '219 application. Vehicles in general are described in column 1, lines 14-16. Specific examples are further described beginning at column 7, line 23.

Independent claim 16 is to a method of applying a fluorocarbon-based polymer coating film to an apparatus. A general description of the method is found at column 1, lines 10-12. Elements a and b of claim 16 are the same as elements a and b of claim 12 in the '219 application.

Applicants request early consideration of this Continuation Reissue Application.


In the event that the transmittal letter is separated from this document and the Patent Office determines that an extension and/or other relief is required, applicant petitions for any required relief including extensions of time and authorizes the Assistant Commissioner to charge the cost of such petitions and/or other fees due in connection with the filing of this document to

Deposit Account No. 03-1952 referencing docket no. 356972000203. However, the Assistant Commissioner is not authorized to charge the cost of the issue fee to the Deposit Account.

Respectfully submitted,

Dated: October 24, 2000

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United States Patent [19]

Ogawa et al.

[54] **METHOD OF MANUFACTURING A
FLUOROCARBON-BASED COATING FILM**

[75] Inventors: **Kazufumi Ogawa, Hirakata; Mamoru
Soga, Osaka, both of Japan**

[73] Assignee: **Matsushita Electric Industrial Co.,
Ltd., Osaka, Japan**

[21] Appl. No. **312,185**

[22] Filed: **Sep. 26, 1994**

Related U.S. Application Data

[60] Continuation of Ser. No. 52,913, Apr. 27, 1993, abandoned,
which is a division of Ser. No. 774,827, Oct. 11, 1991, Pat.
No. 5,240,774.

[30] Foreign Application Priority Data

Oct. 25, 1990 [JP] Japan 2-289127

[51] Int. Cl.⁶ **B05D 3/06**

[52] U.S. Cl. **427/503; 427/536; 427/539;
427/409; 427/412.1; 427/419.7**

[58] Field of Search **428/448; 427/419.8,
427/419.7, 419.1, 412.1, 409, 539, 537,
535, 551, 503, 536**

[56] References Cited

U.S. PATENT DOCUMENTS

4,368,476	12/1983	Uehara et al.	346/140 R
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US005538762A

[11] Patent Number: 5,538,762

[45] Date of Patent: Jul. 23, 1996

4,961,996 10/1990 Carre et al. 428/421

FOREIGN PATENT DOCUMENTS

363924 11/1989 European Pat. Off.
367438 5/1990 European Pat. Off.
386784 9/1990 European Pat. Off.

OTHER PUBLICATIONS

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World Patents Index Latest, Derwent Publications Ltd.,
London, GB: AN 86-065417 & JP-A-61 016 910 (Hitachi
Cable KK), Jan. 24, 1986 (abstract).

Primary Examiner—Shrive Beck
Assistant Examiner—Erma Cameron
Attorney, Agent, or Firm—Fish & Richardson

[57] ABSTRACT

A method of contacting a substrate having a surface containing hydroxyl groups with a non-aqueous solution containing a material having a chlorosilyl group; washing if desired; coating the substrate with a non-aqueous solvent containing a compound having a fluorocarbon group and a chlorosilane group or a solvent containing a compound containing a fluorocarbon group and an alkoxysilane; and baking the substrate if necessary in order to form a fluorocarbon-based polymer coating film chemically bonded to the substrate surface. The hydroxyl groups on the substrate surface and chlorosilyl groups are reacted to form a thin film having a large number of silanol groups ($-\text{SiOH}$) capable of connecting the polymer coating film to the substrate to form a heat-, weather-, and wear-resistant film on various surfaces.

11 Claims, 6 Drawing Sheets

1

METHOD OF MANUFACTURING A FLUOROCARBON-BASED COATING FILM

This application is a continuation of U.S. application Ser. No. 08/052,913, filed Apr. 27, 1993, now abandoned, which was a division of application Ser. No. 07/774,827, filed Oct. 11, 1991, now U.S. Pat. No. 5,240,774.

FIELD OF THE INVENTION

This invention relates to a method of manufacturing a fluorocarbon-based polymer coating film used on an apparatus or the like requiring a heat-resistant, weather-resistant and wear-resistant coating. The coating can be used on electric apparatuses, such as hot plates and rice cooking machines; vehicles; and industrial apparatus.

BACKGROUND OF THE INVENTION

Fluorocarbon-based polymer coating films have been used extensively and are manufactured by making the surface of an Al substrate rough by means of a brush or chemical etching; coating the rough surface with a primer or the like; coating with a paint suspending fine particles of a fluorocarbon-based material, such as polytetrafluoroethylene in ethanol or the like; and then drying and baking at about 400° C. for about one hour to fix the fluorocarbon-based polymer to the substrate surface of the material.

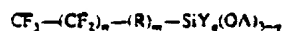
This method of manufacture is simple. However, since the polymer and substrate are bonded together merely by an anchor effect, there is a limit to the adhesion of the polymer to the substrate. The method is insufficient in view of adhesion and mechanical strength as a method of manufacturing fluorocarbon-based coating films used for apparatus or the like requiring a heat-resistant, weather-resistant and wear-resistant coating. Such electric apparatus include hot plates and rice cooking apparatus; vehicles; and industrial apparatus.

SUMMARY OF THE INVENTION

In view of the above drawbacks in the prior art method, it is an object of the present invention to form a fluorocarbon-based coating layer or film having satisfactory adhesion to a substrate that is pinhole-free, thereby improving the performance of an apparatus or the like requiring a heat-resistant, weather-resistant and wear-resistant coating. Such electric apparatuses include hot plates and rice cooking apparatus; vehicles; and industrial apparatus.

The primary objective of this invention is to provide a fluorocarbon-based polymer coating film comprising at least an siloxane film formed as an inner layer and a fluorocarbon-based polymer film formed as an outer layer on the surface of a substrate. The substrate surface and the inner layer are bonded with covalent bonds, and the inner layer and the outer layer are bonded with covalent bonds.

Another objective of this invention is to provide a method of manufacturing a fluorocarbon-based polymer coating film comprising the steps of contacting a substrate having hydroxyl groups on a surface with a non-aqueous solvent containing a material with a chlorosilyl group; coating said substrate surface with either a non-aqueous solvent containing a compound having a fluorocarbon group and a chlorosilyl group or a solvent containing a compound having a fluorocarbon group and alkoxysilane group or a compound represented by the following formula



where n represents 0 or an integer, R represents an [alkyl]alkylene group or a hydrocarbon substituted group containing C=C, C≡C, a silicon atom or an oxygen atom; m represents 0 or 1, Y represents a hydrogen atom, an [alkyl]alkylene group, an alkoxy group, a fluorine-containing alkoxy group or a fluorine-containing [alkyl]alkylene group; A represents a hydrogen atom; and q represents 0, 1 or 2, and, [and] baking the substrate after the contacting and coating steps.

Another objective of this invention is to provide a method of manufacturing a fluorocarbon-based polymer coating film comprising the steps of contacting a substrate having a surface containing hydroxyl groups with a non-aqueous solvent containing a material having a chlorosilyl group; washing the substrate with a non-aqueous solvent to remove the material without reaction; coating the substrate with either a non-aqueous solvent containing a compound having a fluorocarbon group and a chlorosilyl group or a solvent containing a compound having a fluorocarbon group and alkoxysilyl group.

It is preferable in this invention that both sets of the covalent bonds connecting the substrate surface and the inner layer, and the inner layer and the outer layer are siloxane bonds.

It is preferable in this invention that the inner layer is formed with a siloxane-based monomolecular film.

It is preferable in this invention that the substrate is made from a member of a group consisting of metals, ceramics and plastics.

It is preferable in this invention that the substrate is made of a plastic material treated in a plasma atmosphere containing oxygen.

It is preferable in this method invention that the material having a chlorosilyl group contains a member of a group consisting of SiCl_n , SiHCl_3 , SiH_2Cl_2 and $\text{Cl}-(\text{SiCl}_2\text{O})_n-\text{SiCl}_2$ (n being an integer, preferably 1 to 3).

It is preferable in this method invention that the compound having a fluorocarbon group and a chlorosilyl group is represented by a formula: $\text{CF}_3-(\text{CF}_2)_n-(\text{R})_m-\text{SiX}-\text{Cl}_{3-m}$, where n represents 0 or an integer, R represents an [alkyl]alkylene group or a hydrocarbon substituted group containing C=C, C≡C, a silicon atom or a hydrogen atom; m represents 0 or 1, X represents a hydrogen atom, an [alkyl]alkylene group, an alkoxy group, a fluorine-containing alkoxy group or a fluorine-containing [alkyl]alkylene group; p represents 0, 1 or 2.

It is preferable in this method invention that the compound having a fluorocarbon group and an alkoxysilane group is represented by a formula:



where n represents 0 or an integer, R represents an [alkyl]alkylene group or a hydrocarbon substituted group containing C=C, C≡C, a silicon atom or an oxygen atom, m represents 0 or 1, y represents a hydrogen atom, an [alkyl]alkylene group, an alkoxy group, a fluorine-containing alkoxy group or a fluorine-containing [alkyl]alkylene group; OA' represents an alkoxy group; and q represents 0, 1 or 2.

It is preferable in this method invention that the material represented by a formula: $\text{SiX}_3\text{Cl}_{3-s}$, where X represents a hydrogen atom or an [alkyl]alkylene group, and s represents 0, 1 or 2, is added to a non-aqueous solvent containing a compound having a fluorocarbon group and a chlorosilyl group.

It is preferable in this method invention that the material represented by a formula: $\text{SiY}(\text{OA}')_3$, where Y represents an [alkyl]alkylene group; A' represents a hydrogen atom or an [alkyl]alkylene group, and t represents 0, 1 and 2, is added to solvent containing a compound having a fluorocarbon group and an alkoxysilane group.

It is preferable in this method invention that fine particles of a fluorocarbon-based polymer are dispersed in advance in either the non-aqueous solvent containing a compound having a fluorocarbon group and a chlorosilyl group or the solvent containing a compound having a fluorocarbon group and an alkoxysilane group.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1(a) is a schematic sectional view, enlarged in scale to the molecular level showing the surface of a substrate of Example 1 of this invention.

FIG. 1(b) is a schematic sectional view, enlarged in scale to the molecular level showing the siloxane polymer film (inner layer) on the surface of a substrate of Example 1 of this invention.

FIG. 1(c) is a schematic sectional view, enlarged in scale to the molecular level showing the fluorocarbon-based monomolecular coating film on the siloxane polymer film (inner layer) of Example 1 of this invention.

FIG. 1(d) is a schematic sectional view, enlarged in scale to the molecular level showing the fluorocarbon-based polymer (outer layer) and siloxane polymer film (inner layer) on the surface of a substrate of Example 1 of this invention.

FIG. 2(a) is a schematic sectional view, enlarged in scale to the molecular level showing the surface of a substrate of Example 2 of this invention.

FIG. 2(b) is a schematic sectional view, enlarged in scale to the molecular level showing the siloxane monomolecular film (inner layer) on the surface of a substrate of Example 2 of this invention.

FIG. 2(c) is a schematic sectional view, enlarged in scale to the molecular level showing the fluorocarbon-based monomolecular coating film on the siloxane inner layer of Example 2 of this invention.

FIG. 2(d) is a schematic sectional view, enlarged in scale to the molecular level showing the fluorocarbon-based polymer film (outer layer) and siloxane monomolecular film (inner layer) on the surface of a substrate of Example 2 of this invention.

FIG. 3(a) is a schematic sectional view, enlarged in scale to the molecular level showing the surface of a substrate of Example 3 of this invention.

FIG. 3(b) is a schematic sectional view, enlarged in scale to the molecular level showing the siloxane polymer film (inner layer) on the surface of a substrate of Example 3 of this invention.

FIG. 3(c) is a schematic sectional view, enlarged in scale to the molecular level showing the fluorocarbon-based polymer film (outer layer) on the siloxane polymer film (inner layer) of Example 3 of this invention.

FIG. 3(d) is a schematic sectional view, enlarged in scale to the molecular level showing the fluorocarbon-based polymer film (outer layer) and siloxane polymer film (inner layer) on the surface of a substrate of Example 3 of this invention.

FIG. 4(a) is a schematic sectional view, enlarged in scale to the molecular level showing the surface of a substrate of Example 4 of this invention.

FIG. 4(b) is a schematic sectional view, enlarged in scale to the molecular level showing the siloxane polymer (inner layer) on the surface of a substrate of Example 4 of this invention.

FIG. 4(c) is a schematic sectional view, enlarged in scale to the molecular level showing the fluorocarbon-based poly-

mer film (outer layer) on the siloxane polymer film (inner layer) of Example 4 of this invention.

FIG. 4(d) is a schematic sectional view, enlarged in scale to the molecular level showing the fluorocarbon-based polymer film (outer layer) and siloxane polymer film (inner layer) on the surface of a substrate of Example 4 of this invention.

DETAILED DESCRIPTION OF THIS INVENTION

A special feature of manufacturing a fluorocarbon-based coating film, which comprises the steps: contacting a substrate having a surface containing hydroxyl groups with a non-aqueous solvent containing a material having a chlorosilyl group; coating the substrate surface with either a non-aqueous solvent containing a compound having a fluorocarbon group and a chlorosilyl group or a solvent containing a compound having a fluorocarbon group; and alkoxysilane group and baking the substrate after the contacting and coating steps.

A washing step for removing the excess material by washing may be provided between the contacting step and the coating step.

According to the invention, in the step of contacting a substrate having a surface containing hydroxyl groups with a non-aqueous solvent containing a material having a plurality of chlorosilyl groups, the hydroxyl groups on the substrate surface and chlorosilyl groups of the material having chlorosilyl groups are reacted to form on the substrate a thin film having a number of silanol (—SiOH) groups capable of being strongly chemically bonded to the substrate surface.

In addition, after the step of contacting the substrate with a non-aqueous solvent containing a material having chlorosilyl groups, in which the hydroxyl groups on the substrate surface and the chlorosilyl groups of the material are reacted, and the step of removing the non-reacted excess material containing a plurality of chlorosilyl groups remaining on the substrate by washing with non-aqueous organic solvent and by further washing with water, only the material bonded to —OH groups on the substrate can form a siloxane-based monomolecular film (inner layer) containing silanol groups (—SiOH).

Further, after the coating step, in which the substrate is coated with a non-aqueous solvent containing a compound having a fluorocarbon group and a chlorosilane group or with a solvent containing a compound having a fluorocarbon group and an alkoxysilane group, by baking the coating together with the substrate in a moist atmosphere for 1 hour at about 120°C ., a hydrochloric acid removal or alcohol removal reaction during a precipitation step occurs between the mutual chlorosilane groups or alkoxysilane groups in the compound, and between the chlorosilane groups or alkoxysilane groups in the compound, and the —SiOH groups of a thin film formed on the substrate surface. This forms a fluorocarbon-based polymer coating film (outer layer) of a polymer having fluorocarbon groups that is chemically bonded via —SiO— bonds to a thin film formed on the substrate surface and having a large number of —SiOH bonds.

It is thus possible to form a fluorocarbon-based polymer coating film having very excellent adhesion.

For the substrate having a surface containing hydroxyl groups according to the invention, metal and non-metal elements and ceramics may be used.

According to the invention, since hydrophilic groups formed on the substrate and chlorosilyl groups are reacted with each other, where metals are used, commonly termed base metals, such as aluminum, copper and iron, are suitable.

Further, a material without any oxide film such as plastic substrates can be used after surface treatment to render them hydrophilic. The surface treatment may be carried out by usual means, such as treatment in a plasma atmosphere containing oxygen at 100 W, for 20 minutes or a corona treatment. However, plastics that contain —NH groups such as polyamid or polyurethane substrates, do not require surface oxygen treatment. Since —NH groups have active hydrogen, it is easy to remove hydrochloric acid with chlorosilyl groups of the surface active agents.

As the material containing chlorosilyl groups, SiCl_4 , SiHCl_3 , SiH_2Cl_2 and $\text{Cl}-(\text{SiCl}_2\text{O})_n-\text{SiCl}_3$ (n being an integer, preferably 1 to 3) may be used.

When a material having a plurality of chlorosilyl groups in molecule is used, such as $\text{Cl}-(\text{SiCl}_2\text{O})_n-\text{SiCl}_3$, the number of silanol groups on the surface is increased which improve the hydrophilic effect.

As the compound having a fluorocarbon group and a chlorosilane group, those which may be used are represented by a formula: $\text{CF}_3-(\text{CF}_2)_n-(\text{R})_m-\text{SiX}_p\text{Cl}_{3-p}$, where n represents 0 or an integer; R represents an [alkyl] alkylene group or a hydrocarbon substituted group containing $\text{C}=\text{C}$, $\text{C}\equiv\text{C}$, a silicon atom or an oxygen atom; m represents 0 or 1; X represents a hydrogen atom, an [alkyl] alkylene group, an alkoxy group, a fluorine-containing alkoxy group or a fluorine-containing [alkyl] alkylene group; and p represents 0, 1 or 2.

As the compound having a fluorocarbon group and an alkoxysilane group, those which may be used are represented by a formula:



where n represents 0 or an integer; R represents an [alkyl] alkylene group or a hydrocarbon substituted group containing $\text{C}=\text{C}$, $\text{C}\equiv\text{C}$, a silicon atom or an oxygen atom; m represents 0 or 1; Y represents a hydrogen atom, an [alkyl] alkylene group, an alkoxy group, a fluorine-containing alkoxy group and a fluorine-containing [alkyl] alkylene group, OA' represents an alkoxy group, and q represents 0, 1 or 2.

To harden the fluorocarbon-based polymer coating film to be formed, a cross-linking agent can be added.

More specifically, in the case where a non-aqueous solvent containing a compound having a fluorocarbon group and a chlorosilane group is used, a cross-linking which may be used is represented by a formula: $\text{SiX}_s\text{Cl}_{3-s}$, where X represents a hydrogen group or a substituted group, such as

an [alkyl] alkylene group; and s represents 0, 1 or 2. In the case of using a solvent containing a compound having a fluorocarbon group and an alkoxysilane group, a cross-linking agent which may be used is represented by a formula: $\text{SiY}_t(\text{OA}'')_{3-t}$, where Y represents a substituted group, such as an [alkyl] alkylene group; A'' represents a hydrogen atom or an [alkyl] alkylene group, and t represents 0, 1 and 2. In either case, it is possible to adjust the three-dimensional cross-linking degree in the fluorocarbon-based polymer coating film that is formed, thus controlling the hardness of the fluorocarbon-based coating film.

Furthermore, it is possible to coat in ways similar to the prior art fluorocarbon-based coating film by dispersing fine particles of the fluorocarbon-based polymer in a non-aqueous solvent containing a compound having a fluorocarbon group and a chlorosilane group or in a solvent containing a

compound having a fluorocarbon group and an alkoxysilane group. In this case, fluorocarbon chains, siloxane bonds and molecular chains of the fluorocarbon-based polymer entangle on a molecular level with each other. Thus, a fluorocarbon-based polymer coating film may be formed, that has very high adhesion compared to the prior art coating film.

The invention can widely be applied to substrates, such as materials made of metals, ceramics or plastics, wood, stone, etc. The surface of the substrates can also be coated with paints or the like.

Examples of cutlery include: a kitchen knife, scissors, a knife, a cutter, a grater, a razor, hair clippers, a saw, a plane, a chisel, a gimlet, a badkin, bite (cutting tools), the edge of a drill, the edge of a mixer and juicer, a blade of a mill, a blade of a lawnmower, a punch, a straw cutter, a staple of a stapler, a can opener or a surgical knife and the like.

Examples of needles include: an acupuncture needle, a needle, a sewing needle, a matting needle, an injection needle, a surgical needle, a safety pin, and the like.

Examples of products in the pottery (ceramics) industry include: products made of a pottery, a glass, ceramics and enameled products. This further includes, for example, sanitary potteries (a chamber pot, a wash-bowl, a bathtub etc.), tablewares (a rice-bowl, teacup, a dish (plate), a bowl, a teacup, a glass, a bottle, a coffee-pot (siphon), a pan, an earthenware mortar, a cup and the like), vases (a flower bowl, a flowerpot, a bud vase and the like), water tanks (a breeding cistern, an aquarium water tank and the like), chemical experiment appliances (a beaker, a reactor vessel, a test tube, a flask, a laboratory dish, condenser, a mixing rod, stirrer, a mortar, a bat, a syringe etc.) a roof tile, enameled ware, an enameled washbowl, and an enameled pan and the like.

Examples of mirrors include: a hand mirror, a full-length mirror, a bathroom mirror, a lavatory mirror, vehicle mirrors (a rear-view mirror, a side mirror, a door mirror etc.), half mirror, road mirrors such as a curve mirror, a show window glass, a salesroom in the department store, medical care mirrors, a concave mirror, a convex mirror and the like.

Examples of molding parts includes: dies for press molding, dies for cast molding, dies for injection molding, dies for transfer molding, dies for compression molding, dies for transfer molding, dies for inflation molding, dies for vacuum molding, dies for blow forming, dies for extrusion molding, dies for fiber spinning, a calender processing roll and the like.

Examples of ornaments include: a watch, a jewel, a pearl, a sapphire, a ruby, an emerald, a garnet, a cat's eye, a diamond, a topaz, a bloodstone, an aquamarine, a turquoise, an agate, a marble, an amethyst, a cameo, an opal, a crystal, a glass, a ring, a bracelet, a brooch, a tiepin (a stickpin), an earring, a necklace, jewelry made of platinum, gold, silver, copper, aluminium, titanium, tin and those alloy, stainless steel, a glass frame and the like.

Examples of forming molds for food include: cake, cookies, bread-baking, chocolate, jelly, ice cream, ovenware, an ice tray and the like.

Examples of cookware include: kitchen utensils (a pan and a pot), a kettle, a pot, a frying-pan, a hot plate, a roasting net, a takoyaki plate and the like.

Examples of papers include: photogravure paper, hydrophobic and oilphobic paper, poster paper, high-grade pamphlet paper, wrapping paper, package paper, drinking package paper, container paper, printing paper, synthetic insulating paper and the like.

Examples of resin(s) include: a polyolefin such as a polypropylene and polyethylene, a polyvinylchloride plastic,

a polyamide, a polyimide, a polyamideimide, a polyester, an aromatic polyester, a polycarbonate, a polystyrene, a polysulfide, a polysulfone, a polyethersulfone, a polyphenylsulfide, a phenolic resin, a furan resin, a urea resin, an epoxy resin, a polyurethane, a silicon resin, an ABS resin, a methacrylic resin, an acrylate resin, a polyacetal, a polyphenylene oxide, a polymethylpentene, a melamine resin, an alkyd resin, an unsaturated polyester cured resin and the like.

Examples of rubber(s) include: styrene-butadiene rubber, butyl rubber, nitril rubber, chloroprene rubber, polyurethane rubber, silicon rubber and the like.

Examples of household electrical appliances include: a television, a radio, a taperecorder, an audio, a compact disc (CD), a refrigerator of freezing machines, a freezer, an air conditioner, a juicer, a mixer, a blade of an electric fan, a lighting apparatus, a dial plate, a hair dryer for perms and the like.

Examples of sports articles include: skis, fishing rods, poles for polevaulting, boats, yachts, surfboards, golf balls, bowling balls, fishing line (yarn), fishing nets, floats and the like.

Examples applying to vehicle parts include:

(1) ABS resin: a lamp cover, an installment pannel, trimming parts, a protector for a motorcycle.

(2) Cellulose plastic: a car mark, a steering wheel

(3) FRP (fiber reinforced plastics): a bumper, an engine cover (jacket)

(4) Phenolic resin: a brake

(5) Polyacetal: wiper gear, a gas valve

(6) Polyamide: a radiator fan

(7) Polyarylate (polycondensation polymerization by bisphenol A and pseudo phthalic acid): a direction indicator lamp (or lense), a cowl board lense, a relay case

(8) Polybutylene terephthalate (PBT): a rear end, a front fender

(9) Poly(amino-bismaleimide): engine parts, a gear box, a wheel, a suspension drive system

(10) Methacrylate resin: a lamp cover lens, a meter pannel and its cover, center mark

(11) Polypropylene: a bumper

(12) Polyphenylene oxide: a radiator grille, a wheel cap

(13) polyurethane: a bumper, an fender, a installment panel, a fan

(14) Unsaturated polyester resin: a body, a fuel tank, a heater housing, a meter panel.

Examples of office supplies include: a fountain pen, a ball-point pen, a propelling pencil (an automatic or a mechanical pencil), a pencil case, a binder, a desk, a chair, a bookshelf, a rack, a telephone stand table, a ruler (measure), a drawing instrument and the like.

Examples of building materials include: materials for a roof, and outer wall and interiors. Roof materials include a brick, a slate and a tin (a galvanized iron sheet) and the like. Other wall materials include wood (including a processed manufactured wood), mortar, concrete, ceramics sizing, a metallic sizing, a brick, a stone, plastics and a metal like aluminum. Interior materials such as a wood (including a processed one), a metal like aluminum, plastics, paper, fiber and the like.

Examples of building stones include: granite, marble and others used as building material, such as an architecture, an ornament, a bath, a grave, a monument, a gatepost, a stone wall, a paving stone and the like.

Examples of musical instruments and sound apparatus include: a percussion instrument, a stringed instrument, a keyboard instrument, a woodwind instrument, the brass and

others, and sound apparatus such as a microphone, a speaker. To be concrete, there are musical instruments such as a drum, a cymbal, a violin, a cello, a guitar, a koto (harp), a piano, a flute, a clarinet, a bamboo flute and a horn, and sound apparatus such as a microphone, a speaker and a earphone and the like.

Examples also include a thermos bottle, a vacuum bottle, a vacuum vessel and the like.

Examples also include a high resistance voltage insulator, such as a power supplying insulator or a spark plug, which require a highly hydrophobic, oilphobic and prevention of contamination coating.

As has been described in the foregoing, the method of manufacturing a fluorocarbon-based coating film according to the invention comprises the steps contacting a substrate having a surface containing hydroxyl groups with a non-aqueous solution containing a material containing a chlorosilyl group; coating the substrate with a non-aqueous solution containing a compound containing a fluorocarbon group and a chlorosilane group or a solution containing a compound containing a fluorocarbon group and an alkoxysilane group; and baking the substrate after the contacting and coating steps. Thus, a fluorocarbon-based coating film excellent in the hydrophobic and oil-repellent properties can be formed on the surface of a hydrophilic substrate with the properties being strongly chemically bonded to the substrate, high density, no pinholes, uniform thickness and very thin layer. It is thus possible to provide a fluorocarbon-based coating film having high durability and high performance.

Now, examples will be described with reference to FIGS. 1 to 4.

EXAMPLE 1

A hydrophilic substrate 1, i.e., a glass substrate, was prepared as shown in FIG. 1(a).

The substrate 1 was coated with what was obtained by dissolving 1% wt of $\text{Cl}-(\text{SiCl}_2\text{O})_2-\text{SiCl}_2$ as the material having a chlorosilyl group in chloroform solvent.

Also, hydrophilic $-\text{OH}$ substitute groups were contained on the surface of the substrate 1. Thus, a hydrochloric acid removal reaction (dehydrochloric acid) was brought about on the surface to fix molecules to the surface of the substrate 1 via $-\text{SiO}-$ bonds, for example as shown by the formula [1];



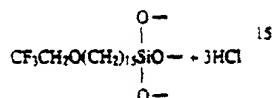
With subsequent evaporation of the chloroform solvent in an atmosphere containing moisture from water content, a siloxane polymer coating film 2 as shown in FIG. 1(b) was formed with hydrochloric acid removal reaction between the moisture and $-\text{Cl}$ groups without being reacted with the substrate 1.

The siloxane polymer coating film 2 thus formed was bonded to the surface of the substrate 1 via chemical bonds of $-\text{SiO}-$ and thus difficult to be separated.

The siloxane polymer coating film 2 had a large number of $-\text{SiOH}$ bonds on the surface.

Accordingly, a solution containing 80% wt n-hexadecane, 12% wt carbon tetrachloride and 8% wt chloroform was prepared by dissolving into a concentration of 2.0% wt $\text{CF}_3\text{CH}_2\text{O}(\text{CH}_2)_{13}\text{SiCl}_3$ as a non-aqueous solvent containing a compound having a fluorocarbon group and a chlo-

rosilane group, and it was coated on the surface of the substrate 1 having the surface thereof formed with the siloxane polymer coating film 2 having a large number of —SiOH bonds, as shown in FIG. 1(c). Then, by baking in an atmosphere containing water moisture at 200° C. for about 30 minutes, a hydrochloric acid removal reaction was brought about between the chlorosilyl groups of fluorine-containing chlorosilane-based surface active agent and exposed —OH groups of the siloxane polymer coating film 2 to form covalent bonds such as the following formula[2];



In this way, a fluorocarbon-based polymer coating film 3 having a thickness of about 10 to 20 μm was obtained.

This polymer film 3 was not separated at all in a check-board test.

Further, by adding 3% wt of SiCl₄ as a cross-linking agent to the non-aqueous solution containing a compound having a fluorocarbon group and a chlorosilane group, a fluorocarbon-based coating polymer film 3 was obtained, which had about two times of the hardness of a solvent without SiCl₄, caused by three-dimensional cross-linking through —Si(O—)₃ bonds.

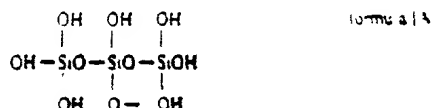
Further by carrying out similar coating by adding 20% wt of fine particles of polytetrafluoroethylene as fluorocarbon-based polymer to the non-aqueous solvent containing a compound having a fluorocarbon group and a chlorosilane group, a fluorocarbon-based coating film was obtained, which had very superior adhesion as compared to that in the prior art even though its hardness was comparable to that in the prior art.

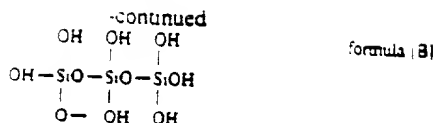
EXAMPLE 2

A hydrophilic substrate 1 was prepared as same as in Example 1, as shown in FIG. 2(a).

The substrate 1 was dipped for about one hour in a solution obtained by dissolving 1% wt of Cl—(SiCl₂O)₂—SiCl₃ as a material having chlorosilyl groups in chloroform solvent as in Example 1. A hydrochloric acid removal reaction thus was brought about on the surface of the substrate 1 because of the presence of hydrophilic —OH groups on the surface to adsorb molecules as shown above formula[1].

By subsequently carrying out washing with a non-aqueous solvent, i.e., chloroform, and then with water, molecules of Cl—(SiCl₂O)₂—SiCl₃ which remained without being reacted with the substrate 1, were removed to leave a siloxane monomolecular film 4 on the surface of the substrate 1 as shown in FIG. 2(b) and given as the formulas [A] and/or [B] etc.

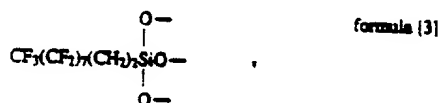




The monomolecular film 4 thus obtained was perfectly bonded to the substrate 1 via chemical bonds of —SiO— and was not easy separated.

The monomolecular film thus formed has many —SiOH bonds on the surface.

Further, a non-aqueous solution containing 80% wt n-hexadecane, 12% wt carbon tetrachloride and 8% wt chloroform was prepared by dissolving into a concentration of 2.0% wt a compound having fluorocarbon group and chlorosilane group such as $\text{CF}_3(\text{CF}_2)_7(\text{CH}_2)_2\text{SiCl}_3$, coated on the surface substrate 1 formed on the surface thereof with a monomolecular film 4 having many —SiOH bonds as shown in FIG. 2(c). A reaction was thus brought about between —SiCl bonds and —SiOH groups of the monomolecular layer 4. Then, by baking in an atmosphere containing water moisture at 200° C. for about 30 minutes, the bonds of formula(3) were formed:



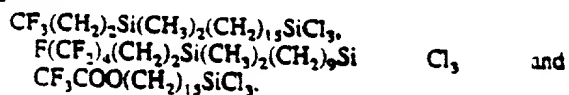
In this way, a polymer film 5 having a thickness of 10 to 20 μm was formed such that it was chemically bonded to the inner-layer, i.e., the siloxane polymer monomolecular film 4.

The coating film did not separate in a checkerboard test.

Furthermore, by adding 15% wt of SiCl_4 as a compound cross-linking agent to the non-aqueous solution containing a compound having a fluorocarbon group and a chlorosilane group, a fluorocarbon-based polymer coating film having a hardness increased by about 5 times could be obtained. Additionally, by carrying out similar coating using a non-aqueous solution containing a compound having a fluorocarbon group and a chlorosilane group, which was obtained by dispersing about 20% wt of fine particles of a fluorocarbon-based polymer, e.g., polytetrafluoroethylene, a fluorocarbon-based polymer coating film could be obtained that had very superior adhesion compared to that in the prior art although its hardness was comparable to that in the prior art.

While this example used $\text{CF}_3\text{CH}_2\text{O}(\text{CH}_2)_{11}\text{SiCl}_3$ and $\text{CF}_3(\text{CF}_2)_7(\text{CH}_2)_2\text{SiCl}_3$ as the fluorocarbon-based surface active agent, by adding the $\text{C}=\text{C}$ or $\text{C}\equiv\text{C}$ group to or assembling it in an [alkyl]alkylene chain portion, cross-linking can be obtained by irradiation with an electron beam of about 5M-rads after the formation of the coating film, and thus it is possible to increase the hardness of the coating film to about 10 times.

Further, as the fluorocarbon-based surface active agent, materials shown below may be used in addition to the above agents,



EXAMPLE 3

As shown in Example 1, a hydrophilic substrate 11 was prepared as shown in FIG. 3(a).

This substrate 11 was then dipped in a solution obtained by dissolving 1% wt of a material having a chlorosilyl group

in a non-aqueous solvent such as a chloroform solvent and then was raised from the solution.

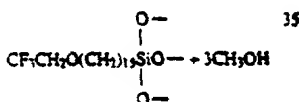
By using $\text{Cl}-(\text{SiCl}_2\text{O})_2-\text{SiCl}_3$ as a material having a plurality of chlorosilyl groups in a molecule, a hydrochloric acid removal reaction was brought about because of the presence of hydrophilic $-\text{OH}$ groups on the surface of the substrate 11, thus fixing molecules to the substrate via $-\text{SiO}-$ bonds as shown above formula [1].

By subsequently evaporating the chloroform solvent in an atmosphere containing of moisture, chlorine in $-\text{SiCl}$ groups that remained without being reacted with the substrate 11 were then reacted with the water by a hydrochloric acid removal reaction to form a siloxane polymer coating film 12 as shown in FIG. 3(b).

As the siloxane polymer coating film 12 thus obtained was bonded to the surface of the substrate 11 via chemical bonds of $-\text{SiO}-$, it was difficult to be separated.

The siloxane polymer coating film 12 formed also had many $-\text{SiOH}$ bonds on the surface.

Furthermore, a solution obtained by dissolving a concentration of several percent, for instance 10% wt, of a compound having a fluorocarbon group and a alkoxysilane group, for instance $\text{CF}_3\text{CH}_2\text{O}(\text{CH}_2)_3\text{Si}(\text{OCH}_3)_3$ in an alcohol solvent, for instance ethanol, was used for coating, followed by baking at 200°C . for about 30 minutes. By doing so, $-\text{OH}$ groups exposed to the surface of the siloxane polymer coating film 12 were reacted with alkoxy groups in the fluorine-containing alkoxysilane-based surface active agent an alcohol removal reaction to form such as the formula [4].



In this way, a polymer film 13 having a thickness of 10 to 20 μm was obtained.

This polymer film 13 did not separate in a checkerboard test. Further, by adding 5% wt of $\text{Si}(\text{OCH}_3)_4$ as a cross-linking agent to the solvent containing a compound having a fluorocarbon group and an alkoxysilane group shown by the above formula [4], a three-dimensionally cross-linked fluorocarbon-based film via $-\text{SiCl}(-\text{O}-)_2$ bonds was obtained, which had about two times the hardness of the film obtained without addition of $\text{Si}(\text{OCH}_3)_4$.

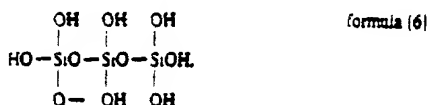
Further, by carrying out similar coating using a solution containing a compound having a fluorocarbon group and an alkoxysilane group, to which 20% wt of fine particles of polytetrafluoroethylene were added as a fluorocarbon-based polymer, a polymer film was obtained, which had a very superior adhesion compared to that in the prior art although its hardness was comparable to that in the prior art.

EXAMPLE 4

As shown in Example 3, a hydrophilic substrate 11 as shown in FIG. 4(a) was dipped for about one hour in a non-aqueous solution prepared by dissolving 1 % wt of $\text{Cl}-(\text{SiCl}_2\text{O})_2-\text{SiCl}_3$ as a material containing a chlorosilyl group, for instance, in a chloroform solvent.

At this time, hydrochloric acid removal reaction occurred on the surface of substrate 11 because of the presence of hydrophilic $-\text{OH}$ groups on the surface. Thus, molecules

were adsorbed as shown by the formula such as formula [1]. When the substrate was exposed to an atmosphere containing water, a siloxane monomolecular film 14 as shown in FIG. 4(b) was obtained on the substrate surface, and shown such as the formula [5] and/or formula [6] etc.



The monomolecular layer 14 thus obtained did not separate as it was perfectly bonded to the substrate 1 via —SiO— chemical bonds.

The monomolecular layer 14 obtained also had many —SiOH bonds.

Further, a solution was prepared by dissolving a concentration of 2% wt $\text{CF}_3(\text{CF}_2)_7(\text{CH}_2)_2\text{Si}(\text{OC}_2\text{H}_5)_3$ as a compound having a fluorocarbon group and an alkoxysilane group in a methanol solvent, coated onto the surface of substrate 11 covered with a monomolecular film having many —SiOH bonds, and followed by baking at 200° C. for about 30 minutes.

This produced the compound shown in FIG. 4(d) and represented by formula[7].



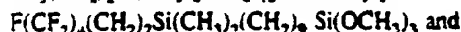
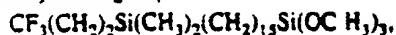
In this way, a polymer film 15 having a thickness of 10 to 20 μm was obtained.

The polymer film 15 formed did not separate in a check-board test, because it was formed in a state chemically bonded to the siloxane monomolecular film 14.

Further, by adding 10% wt of $\text{Si}(\text{OC}_2\text{H}_5)_4$ as the cross-linking agent to the solution having a compound containing a fluorocarbon group and an alkoxysilane group, a fluorocarbon-based coating film having about four times the hardness of the film was obtained as compared to a film without the addition of the agent. Furthermore, by carrying out similar coating using a solution containing a compound having a fluorocarbon group and an alkoxysilane group, in which solution was dispersed 20% wt of fine particles of polytetrafluoroethylene, a fluorocarbon-based coating film was obtained, which had a very superior adhesion compared to that in the prior art although its hardness was comparable to that in the prior art.

Although in the above Examples 3 and 4, $\text{CF}_3\text{CH}_2\text{O}(\text{CH}_2)_{13}\text{Si}(\text{OCH}_3)_3$ and $\text{CF}_3(\text{CF}_2)_7(\text{CH}_2)_2\text{Si}(\text{OC}_2\text{H}_5)_3$ were used as a reagent for forming a fluorocarbon-based film on the uppermost surface by adding or assembling the C=C or C≡C group to or in the alkyl chain portion, cross-linking can be caused by irradiation of an electron beam of about 5M-rads. After the formation of the coating film, a coating film with about 10 times of the hardness to be obtained.

Further, as the compound having a fluorocarbon group and a chlorosilyl group or a fluorocarbon group and an alkoxysilane group,



$\text{CF}_3\text{COO}(\text{CH}_2)_{13}\text{Si}(\text{OC}_2\text{H}_5)_3$ may be used, in addition to the compounds noted in the above Examples 1 to 4.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is to be considered in all respects as illustrative and not restrictive. The scope of the invention is indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are intended to be embraced therein.

We claim:

1. A method of manufacturing a fluorocarbon-based polymer coating film comprising the steps of:

contacting a substrate having a surface containing hydroxyl groups with a non-aqueous solvent comprising a material comprising chlorosilyl groups;

coating the contacted substrate surface with either (1) a non-aqueous solvent comprising a compound comprising a fluorocarbon group and a chlorosilyl group or (2) a solvent comprising (a) a compound comprising a fluorocarbon group, and an alkoxysilyl [alkoxysilane] group or (b) a compound of the following formula:



where n represents 0 or an integer; R represents an alkyl group or a hydrocarbon substituted group containing $\text{C}=\text{C}$ or $\text{C}\equiv\text{C}$, a silicon atom or an oxygen atom; m represents 0 or 1; Y represents a hydrogen atom, an [alkyl]alkylene group, an alkoxy group, a fluorine-containing alkoxy group or a fluorine-containing [alkyl]alkylene group; A represents a hydrogen atom, q represents 0, 1 or 2; and

baking the substrate after said contacting step and coating step.

2. The method of manufacturing the fluorocarbon-based polymer coating film according to claim 1, wherein the substrate is made of the member of a group consisting of glass, metals, plastics and ceramics.

3. The method of manufacturing the fluorocarbon-based polymer coating film according to claim 1, wherein the substrate is [made] made of a plastic material treated in a plasma atmosphere containing oxygen.

4. The method of manufacturing the fluorocarbon-based polymer coating film according to claim 1, wherein said material comprising chlorosilyl groups comprises a member of the group consisting of SiCl_4 , SiHCl_3 , SiH_2Cl_2 and $\text{Cl}-(\text{SiCl}_2\text{O})_n-\text{SiCl}_3$, wherein n is an integer.

5. A method of manufacturing the fluorocarbon-based polymer coating film according to claim 1, wherein said compound having a fluorocarbon group and a chlorosilyl group is represented by a formula: $\text{CF}_3-(\text{CF}_2)_n-(\text{R})_m-\text{SiX}_p\text{Cl}_{3-p}$, where n represents 0 or an integer; R represents an [alkyl]alkylene group or a hydrocarbon substituted group containing $\text{C}=\text{C}$, $\text{C}\equiv\text{C}$, a silicon atom or an oxygen atom; m represents 0 or 1; X represents a hydrogen atom, an [alkyl]alkylene group, an alkoxy group, a fluorine-containing alkoxy group, or a fluorine-containing [alkyl]alkylene group; p represents 0, 1 or 2.

6. A method of manufacturing the fluorocarbon-based polymer coating film according to claim 1, wherein said compound (a) is represented by a formula:



where n represents 0 or an integer;

R represents an [alkyl]alkylene group or a hydrocarbon substituted group containing $\text{C}=\text{C}$ or $\text{C}\equiv\text{C}$, a silicon atom or an oxygen atom;

m represents 0 or 1.

Y represents a hydrogen atom, an [alkyl] alkylene group, an alkoxy group, a fluorine-containing alkoxy group or a fluorine-containing [alkyl] alkylene group.

OA' represents an alkoxy group; and

q represents 0, 1 or 2.

7. A method of manufacturing the fluorocarbon-based polymer coating film according to claim 1, wherein a material represented by a formula: SiXCl_{3-m} , where X represents a hydrogen atom or an [alkyl] alkylene group, and s represents 0, 1 or 2, is added to the non-aqueous solvent containing the compound having a fluorocarbon group and a chlorosilyl group

8. The method of manufacturing the fluorocarbon-based polymer coating film according to claim 1, wherein a material represented by a formula:



where Y represents an [alkyl] alkylene group; A' represents atom or an [alkyl] alkylene group; and t represents 0, 1, and to the solvent of (2).

9. The method of manufacturing the fluorocarbon-based polymer coating film according to claim 1, wherein fine particles of a fluorocarbon-based polymer are dispersed in advance in either said non-aqueous solvent containing the compound having a fluorocarbon group and a chlorosilyl group or said solvent containing the compound having a fluorocarbon group and an alkoxysilane group.

10. A method of manufacturing a fluorocarbon-based polymer coating film comprising the steps of:

contacting a substrate having a surface containing hydroxyl groups with a non-aqueous solvent comprising a material comprising chlorosilyl groups;

washing the contacted substrate with a non-aqueous solvent to remove unreacted material;

coating the washed substrate surface with either (1) a non-aqueous solvent comprising a compound comprising a fluorocarbon group and a chlorosilyl group or (2) a solvent comprising (a) a compound comprising a fluorocarbon group, and an alkoxysilyl [alkoxysilane] group or (b) a compound of the following formula:



where n represents 0 or an integer; R represents an [alkyl] alkylene group or a hydrocarbon substituted group containing C=C, C≡C, a silicon atom or an oxygen atom; m represents 0 or 1, Y represents a hydrogen atom, an [alkyl] alkylene group, an alkoxy group, a fluorine-containing alkoxy group or a fluorine-containing [alkyl] alkylene group; A represents a hydrogen atom; and q represents 0, 1 or 2; and

baking the substrate after said contacting step, washing step and coating step

11. A method of manufacturing the fluorocarbon-based polymer coating film of claim 1, further comprising:

irradiating with an electron beam of about 5M-rads when the fluorocarbon group of the coating step comprises C=C or C≡C bonds, which irradiation is performed subsequent to the coating step and prior to the baking step.

12. A method of manufacturing a fluorocarbon-based polymer coating film comprising the steps of:

- a. contacting a substrate having a surface containing hydroxyl groups with a non-aqueous solvent comprising a material comprising chlorosilyl groups to form a siloxane-based film on the substrate surface; and
- b. coating the siloxane-based film with either (1) a non-aqueous solvent comprising a compound comprising a fluorocarbon group and a chlorosilyl group or (2) a solvent comprising a compound comprising a fluorocarbon group and an alkoxysilyl group.

13. The method of manufacturing the fluorocarbon-based polymer coating film according to claim 12, wherein the substrate is made of the member of a group consisting of glass, metals, plastics, and ceramics.

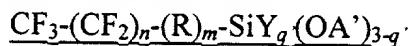
14. The method of manufacturing the fluorocarbon-based polymer coating film according to claim 12, wherein the substrate is made of a plastic material treated in a plasma atmosphere containing oxygen.

15. The method of manufacturing the fluorocarbon-based polymer coating film according to claim 12, wherein said material comprising chlorosilyl groups is selected from the group consisting of SiCl_4 , SiHCl_3 , SiH_2Cl_2 and $\text{Cl}-(\text{SiCl}_2\text{O})_n-\text{SiCl}_3$, wherein n is an integer.

16. The method of manufacturing the fluorocarbon-based polymer coating film according to claim 12, wherein said compound comprising a fluorocarbon group and a chlorosilyl group is represented by a formula: $\text{CF}_3-(\text{CF}_2)_n-(\text{R})_m-\text{SiX}_p\text{Cl}_{3-p}$ where n represents 0 or an integer; R represents an alkylene group or a hydrocarbon substituted group containing $\text{C}=\text{C}$ or $\text{C}\equiv\text{C}$, a silicon atom or an oxygen atom; m represents 0 or 1, X

represents a hydrogen atom, an alkyl group, an alkoxy group, a fluorine-containing alkoxy group or a fluorine-containing alkyl group; p represents 0, 1 or 2.

17. The method of manufacturing the fluorocarbon-based polymer coating film according to claim 12, wherein the compound comprising a fluorocarbon group and a chlorosilyl group is represented by:



where n represents 0 or an integer;

R represents an alkylene group or a hydrocarbon substituted group containing C=C or C≡C, a silicon atom or an oxygen atom;

m represents 0 or 1;

Y represents a hydrogen atom, an alkyl group, an alkoxy group, a fluorine-containing alkoxy group or a fluorine-containing alkyl group;

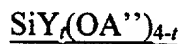
OA' represents an alkoxy group; and

q' represents 0, 1 or 2;

and the method further comprises a step of baking the substrate after coating.

18. The method of manufacturing the fluorocarbon-based polymer coating film according to claim 16, wherein a material represented by a formula: $\text{SiX}_s\text{Cl}_{4-s}$ where X represents a hydrogen atom or an alkyl group, and s represents 0, 1 or 2; is added to the solvent of (1).

19. The method of manufacturing the fluorocarbon-based polymer coating film according to claim 12, wherein a material represented by a formula:



where Y represents an alkyl group; A'' represents a hydrogen atom or an alkyl group; and t represents 0, 1, and 2; is added to the solvent of (2).

20. The method of manufacturing the fluorocarbon-based polymer coating film according to claim 12, wherein fine particles of a fluorocarbon-based polymer are dispersed in advance in either said non-aqueous solvent containing the compound comprising a fluorocarbon group and a chlorosilyl group or said solvent containing the compound comprising a fluorocarbon group and an alkoxysilyl group.

21. A method of producing a non-wetting surface on a glass substrate comprising the steps of:

- a. depositing a siloxane-based primer layer on a surface of the glass; and
- b. coating the siloxane-based primer layer with a composition comprising a perfluoroalkyl alkyl silane.

22. A product made by the process of claim 16.

23. A product made by the process of claim 17.

24. A product made by the process of claim 18.

25. A product made by the process of claim 19.

26. A product made by the process of claim 21.

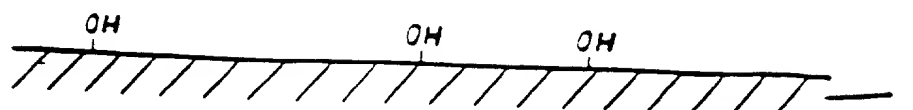


FIG. 1(a)

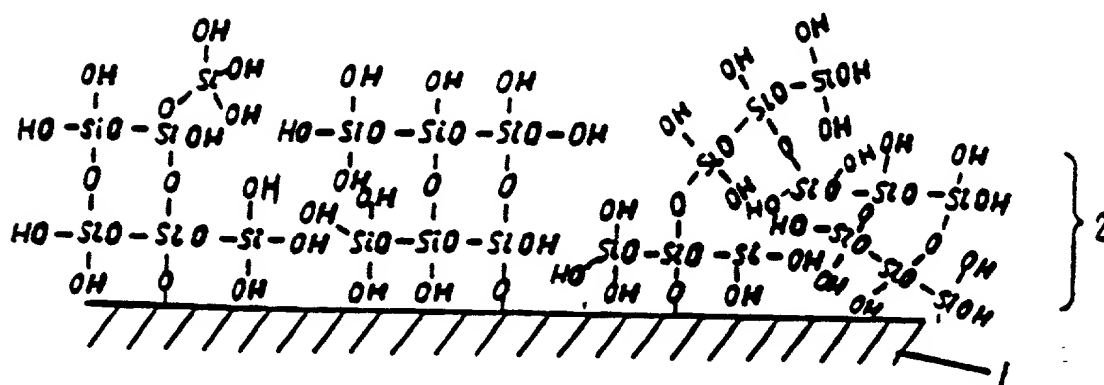


FIG. 1(b)

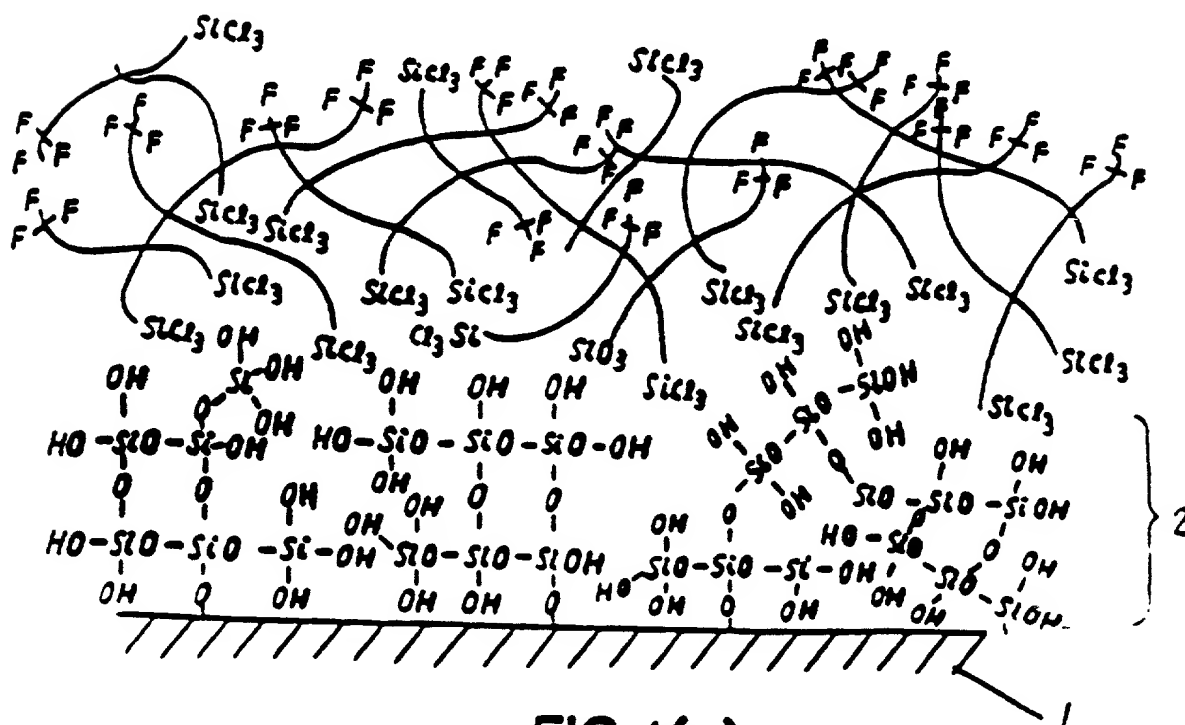


FIG. 1(c)



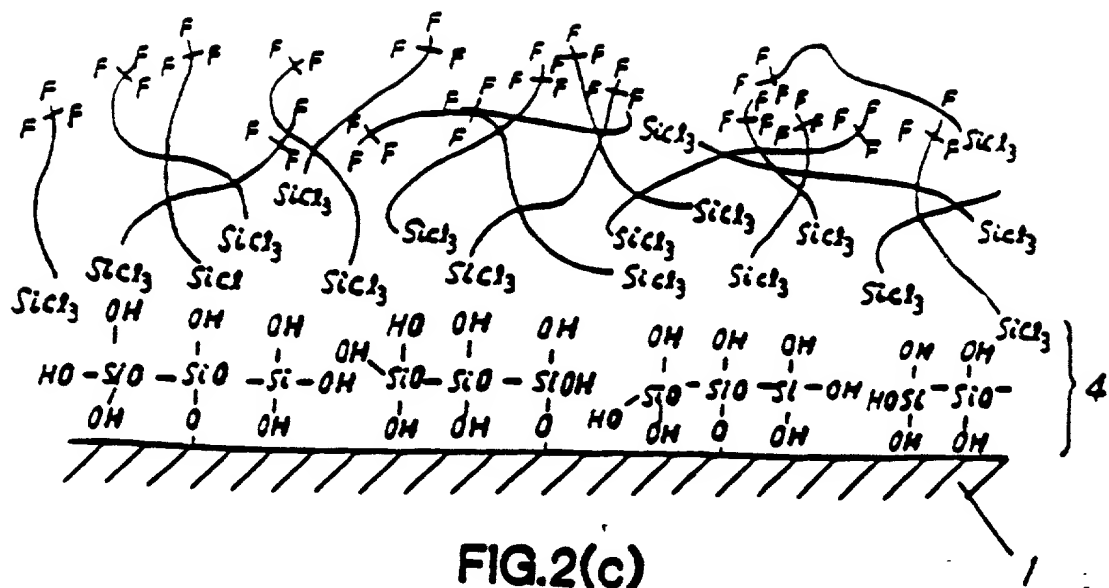


FIG. 2(c)

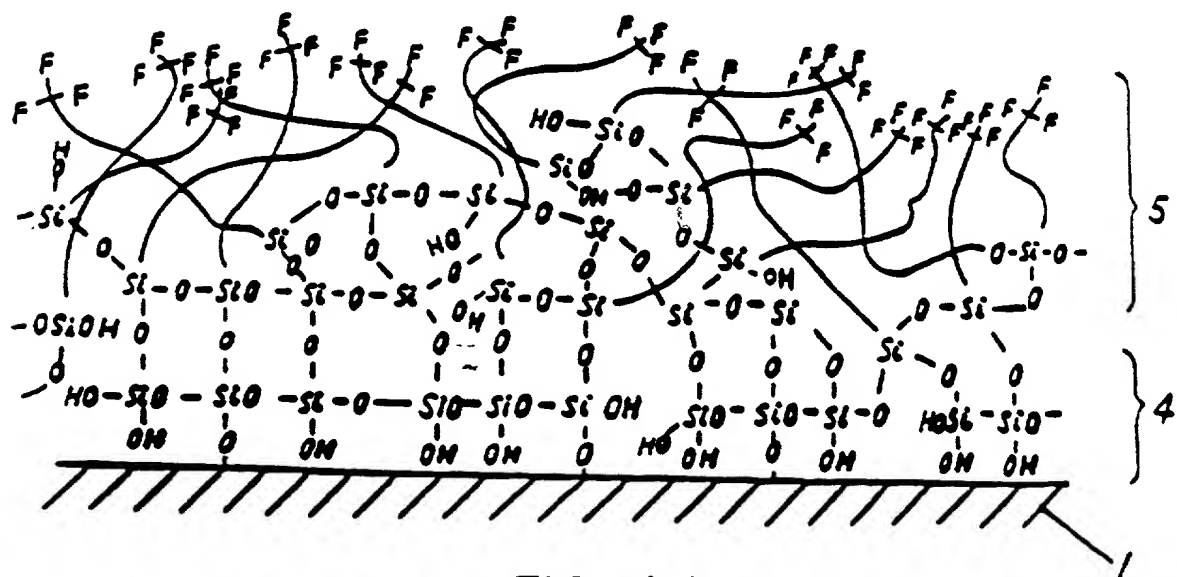


FIG.2(d)

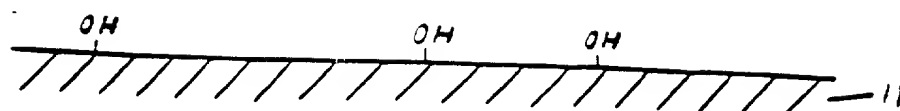


FIG. 3(a)

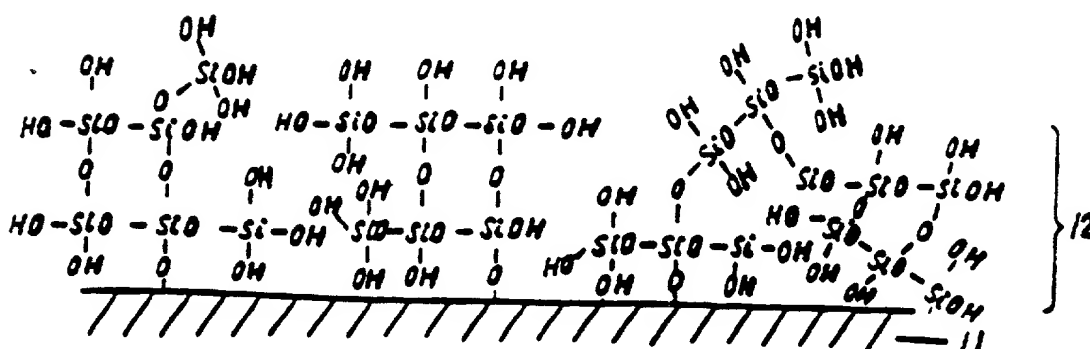


FIG. 3(b)

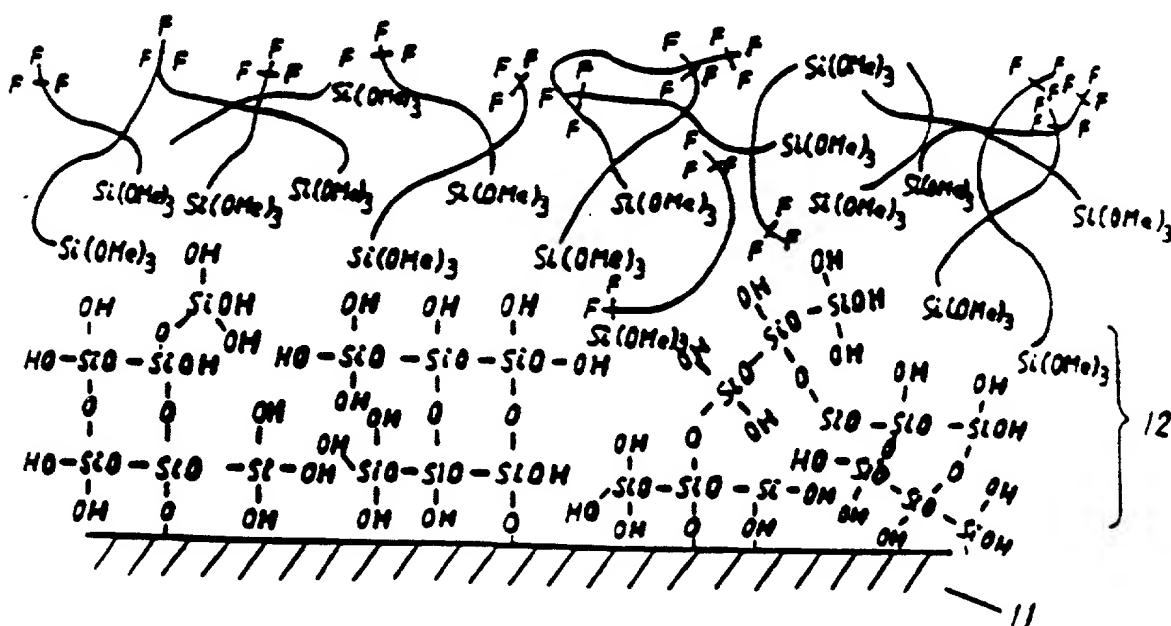


FIG. 3(c)

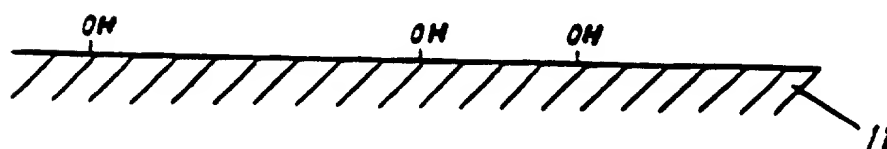


FIG.4(a)

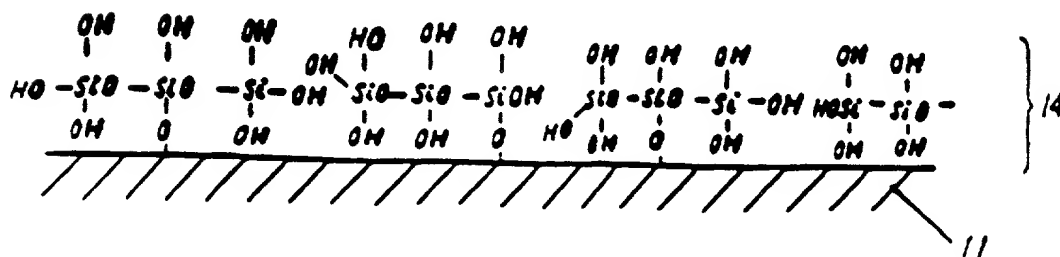


FIG.4(b)

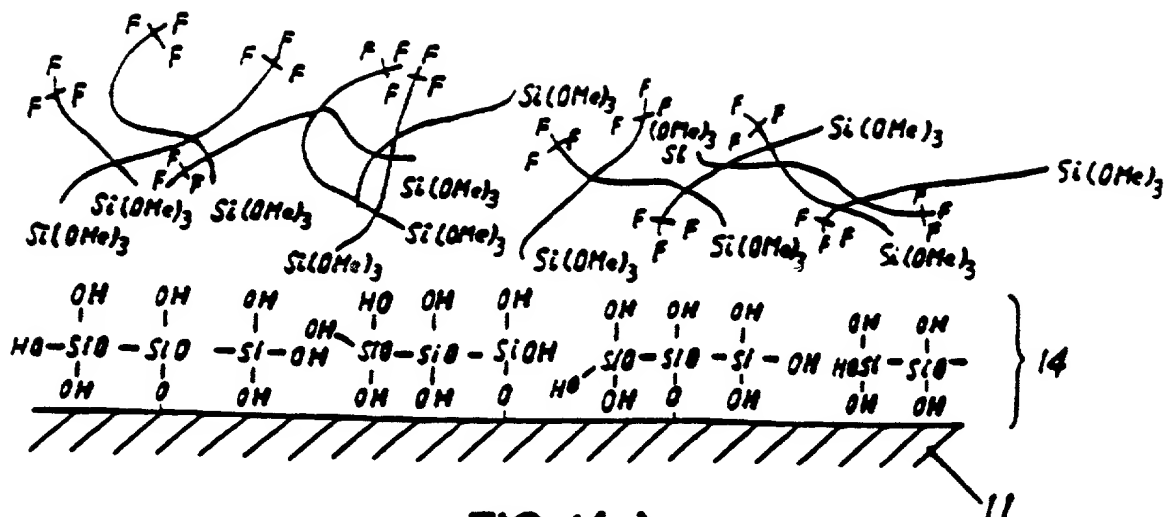


FIG.4(c)

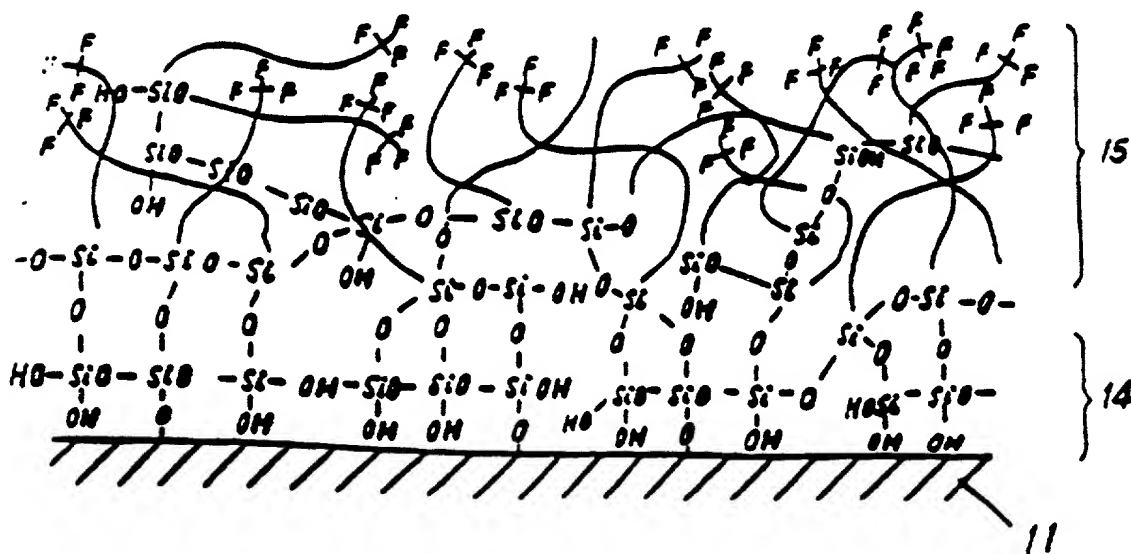


FIG.4(d)

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Elizabeth K. Stenson
Elizabeth K. Stenson

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the Reissue application of:

Kazufumi OGAWA et al.

Original U.S. Patent No.: 5,538,762

Original Issue Date: July 23, 1996

Reissue Serial No.: 09/112,219

Reissue Filing Date: July 9, 1998

For: METHOD OF MANUFACTURING A
FLUOROCARBON-BASED COATING
FILM

Examiner: Cameron, E.

Group Art Unit: 1762

**SUPPLEMENTAL
REISSUE APPLICATION DECLARATION AND
POWER OF ATTORNEY BY INVENTOR**

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name. I believe I am an original, first and joint inventor of the subject matter that is described and claimed in U.S. Patent No. 5,538,762, granted on July 23, 1996, and for which a reissue patent is sought in the invention entitled "Method of Manufacturing a Fluorocarbon-Based Coating Film,"

the specification of which was filed on July 9, 1998 as reissue application number 09/112,219, and was amended on January 14, 1999 and June 23, 1999.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendments referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with 37 C.F.R. § 1.56(a) and (b).

I verily believe the original patent to be wholly or partly inoperative or invalid by reason of claiming more or less than I had the right to claim in the patent.

At least one error upon which reissue is based is described as follows: Claim 1 includes an additional, non-necessary step when a specific siloxane-based film is used, which is corrected by the addition of claim 12.

I hereby state that all errors corrected in this reissue application arose without any deceptive intention.

I hereby claim foreign priority benefits under 35 U.S.C. § 119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

Application No. 289127/1990

Country Japan

Filing Date 10/25/90

POWER OF ATTORNEY

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith

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Edward V. Donahue (Reg No. 35,492)
Thomas G. Wiseman (Reg No. 35,046)
Ararat Kapouytian (Reg No. 40,044)
Richard D. Jordan (Reg No. 33,519)

all of Morrison & Foerster LLP, 2000 Pennsylvania Avenue, N.W., Washington, D.C. 20006-1888, telephone (202) 887-1500, to prosecute this application and transact all matters in the United States Patent and Trademark Office connected therewith.

Please direct all written communications relative to this application to:

Richard D. Jordan
Morrison & Foerster LLP
2000 Pennsylvania Avenue, N.W.
Washington, D.C. 20006-1888

Please direct all telephone communications to Richard D. Jordan at (202) 887-6930.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under § 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

July 27, 1999
Date

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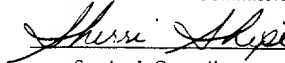
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Sandra J. Connella

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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Original Issue Date: July 23, 1996

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FILM

Examiner:

Group Art Unit:

REISSUE APPLICATION DECLARATION AND POWER OF ATTORNEY
BY INVENTOR

Box 7
Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

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Citizenship: Japanese
Post Office Address: Same as residence